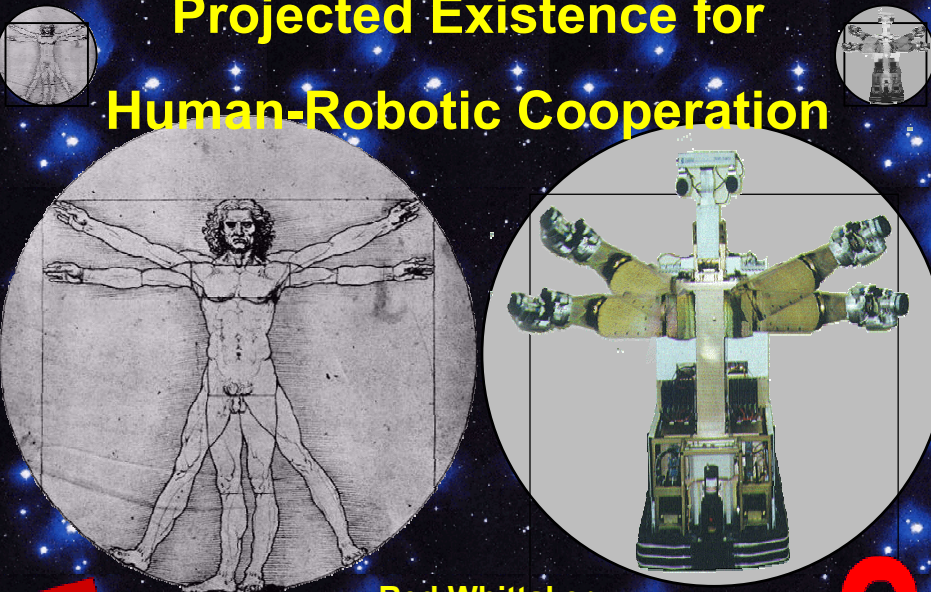


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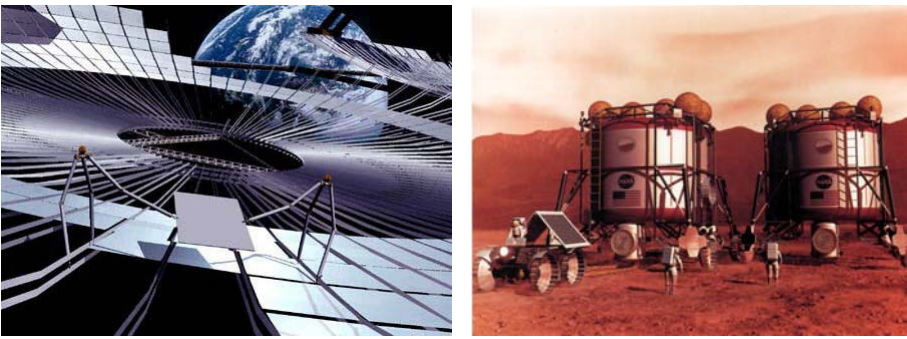


**Red Whittaker
Robotics Institute
Carnegie Mellon University**

Carnegie Mellon
November 16, 2001

THE ROBOTICS INSTITUTE

Projected Existence



**Collaborative
Exploration, Enterprise and expansion of
Human Experience**

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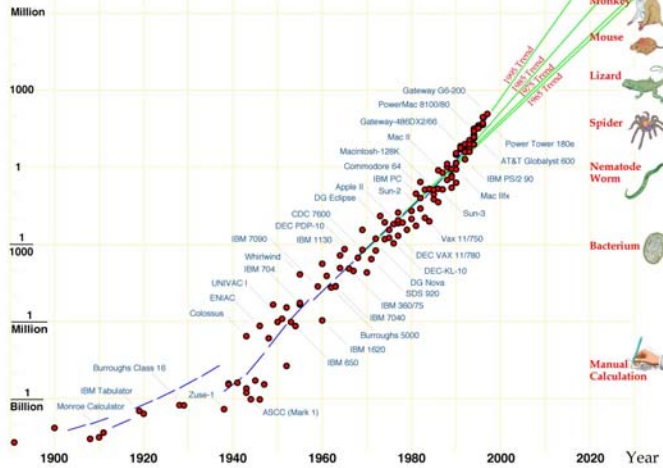


Computing Evolution



Evolution of Computer Power/Cost

MIPS per \$1000 (1997 Dollars)



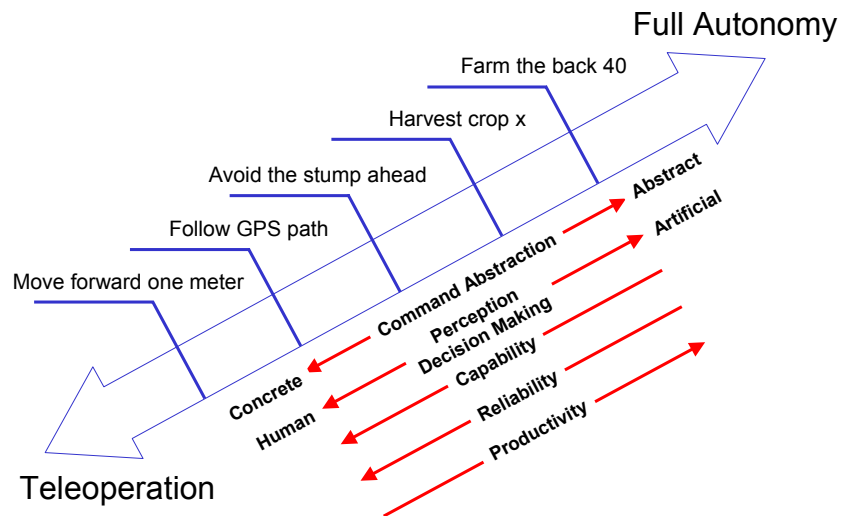
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3




Sliding Autonomy




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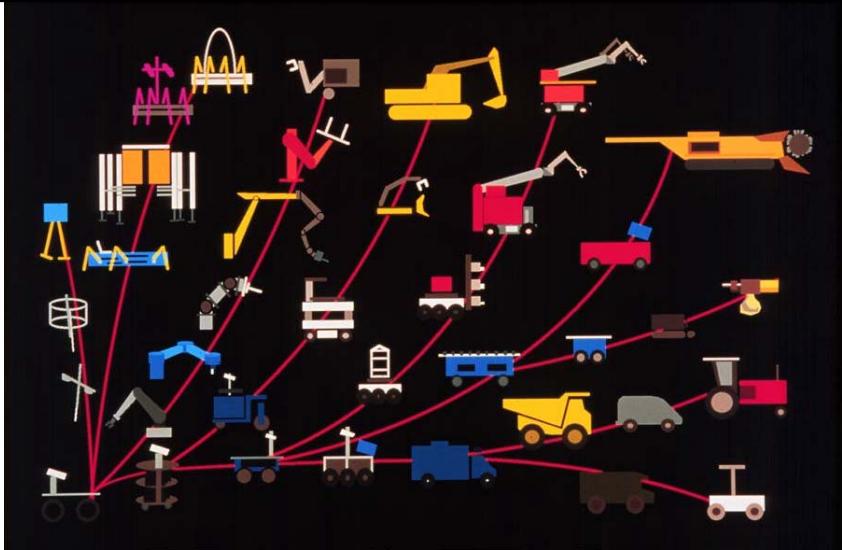
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Robotic Evolution







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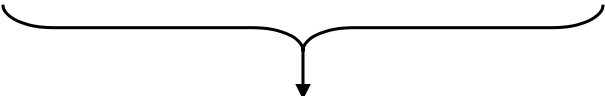
5



Limitations of Machines



- Distance
- Power
- Mass
- Bandwidth
- Time
- Cost



Symptoms of a fundamental problem:
the **one-to-one** link between man and
machine

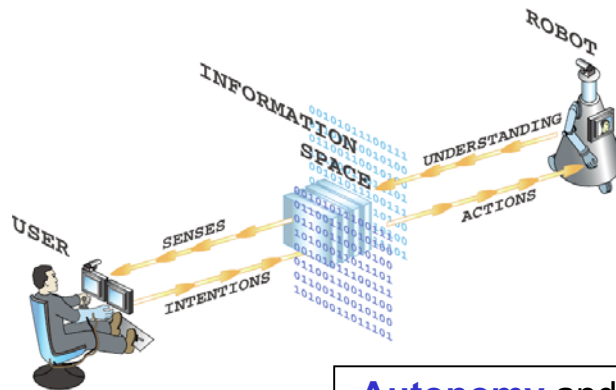
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6



Breaking the Link



Autonomy and **collaboration**
break the direct link
between man and machine

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7



Information Interaction



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8

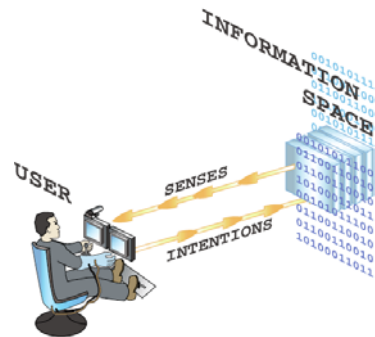


High-Level Interaction



Result is a **supervisor – employee** model of interaction

- Humans communicate their intentions at a high level
- Robots report summaries and explanations of their observations and understanding



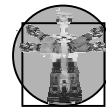
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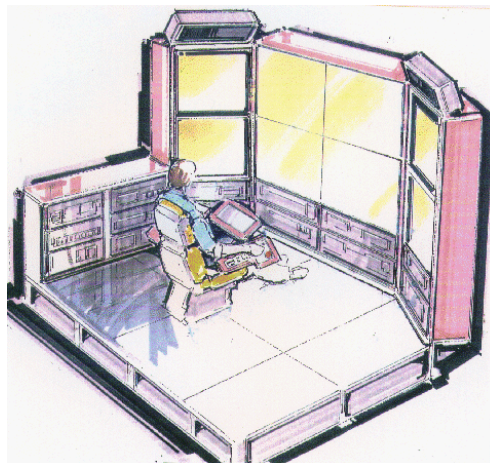
9



PE Interface



- High-level expression of intentions
- High-level summaries and explanations of results
- Self-understanding of capabilities



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10



Robocon



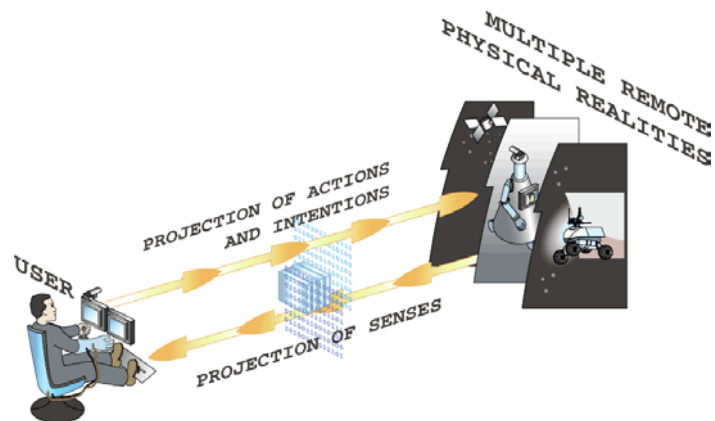
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11



Multiple Realities



Human is freed to control **multiple** robots,
in multiple locations

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12



Beyond Multiple Robots in Single Reality



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13



Multiple Realities



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14



Collaboration



- Humans-Robot collaboration
 - Navigation interaction
 - Following, leading
 - Dialog interaction
 - Forceful interaction
 - Digging, pulling, support
 - Planning interaction



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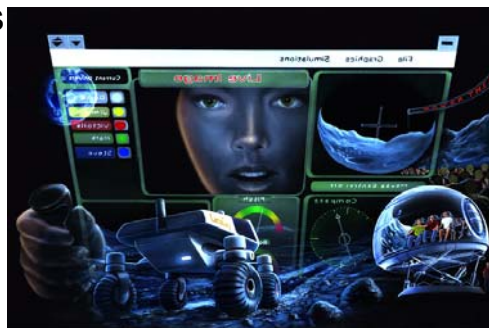
15



Skills for Collaboration



- In order to collaborate with humans, robots must be able to:
 - Exhibit task competence
 - Interact with humans
 - Observe humans
 - Model humans
 - Predict humans



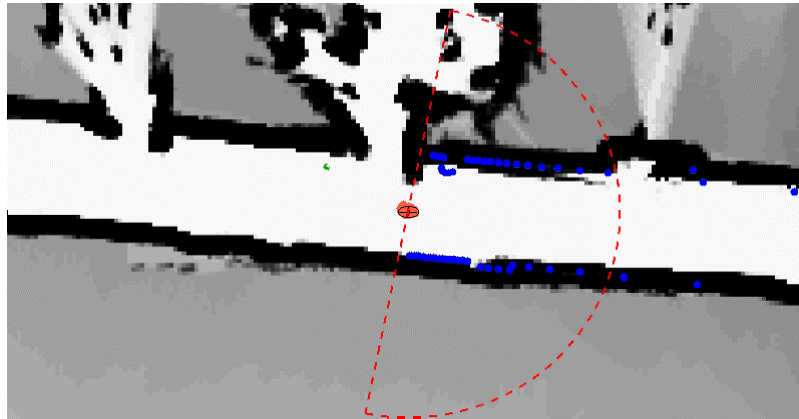
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16



Leader - Follower



Probabilistic People Tracking

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Voice Interaction



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18



Gesture Interaction



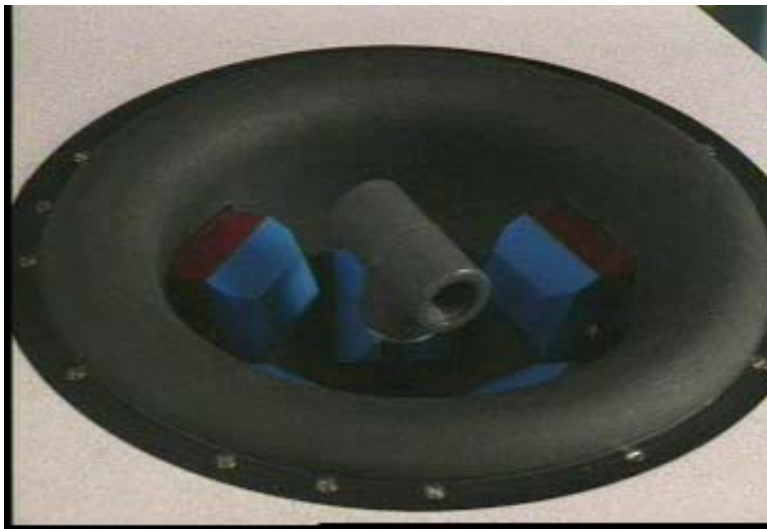
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19



Feel



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20



Exoskeletal Touch



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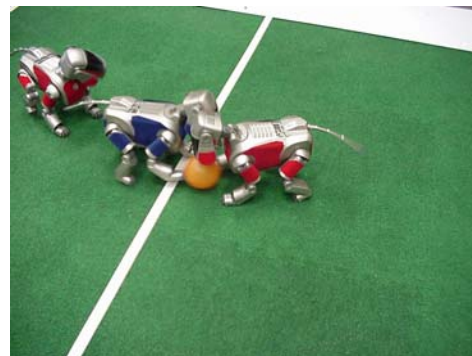
21



Planning Interaction



- Adversarial and collaborative planning
- Real-time opponent modeling
- Dynamic behavior



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22



Proximity Collaboration



- Medication reminding
- Medical monitoring
- Dialog interaction
- Walking assistance



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23



Proximity Interaction



Nursebot Pearl

Assisting Nursing
Home Residents

Longwood, Oakdale, May 2001
CMU/Pitt/Mich Nursebot Project



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24



PE Technologies



- Advanced Robot Autonomy
- Intelligent Sensing
- Advanced Robot Platforms
- High-Level Interfaces
- Human-Robot Interpreters
- Proprioception
- Uncertainty and Risk - Robots must have some understanding of the conditions under which their internal models are applicable

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25



Projected Existence



Projected Existence dramatically increases human productivity by allowing individuals to simultaneously engage in multiple physical realities. This capability goes beyond switching among multiple traditional telepresence interfaces. Traditionally, remote agents sit dormant while they are not being teleoperated, producing little benefit in terms of productivity. In order to take full advantage of multiple remote interfaces, humans and machines must share control. While humans are not supervising a remote location, their surrogates must autonomously implement the human's projected intentions. When human attention returns to that location, the remote agent passes back control. This implementation of human intentions in multiple realities without persistent human attention is Projected Existence.

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26

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